Wharton
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MACK INSTITUTE
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Deploying Artificial Intelligence

Unlocking the strategic potential, avoiding pitfalls, and getting the organization ready

Contents

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By Pragna Kolli and Mack Institute Executive Director Saikat Chaudhuri

The Proof and the Promise

Artificial intelligence (AI) is the linchpin of many technological innovations today and embedded everywhere, even if we don't realize it. Adoption of AI has led to transformations in almost every industry in the past decade, from retail to transportation services, supply chain, financial services, healthcare, manufacturing, and more.

"Alibaba" once evoked the memory of the prudent woodcutter in Arabian Nights tales. Today, instead, the word brings to mind the Chinese multinational conglomerate that operates one of the world's largest e-commerce platforms. From designing chatbots for deciphering consumer emotions to robots for packing and delivering, for facial and voice recognition on pig farms, for seamless payment systems, for monitoring traffic and reducing road congestion, and even for prolific content writing, Alibaba has leveraged the power of machine learning (ML) and AI algorithms and put them to incredible uses.[1]

1 Abigail Beall, "In China, Alibaba's data-hungry AI is controlling (and watching) cities," *WIRED*, May 30, 2018, https://www.wired.co.uk/article/alibaba-city-brain-artificial-intelligence-china-kuala-lumpur. Alibaba even rewired Shanghai's subways where customers' faces are identified even as they walk through the barriers without touching a screen or talking to a person, route recommendations are set up, voices and even accents are parsed, and ticket purchases arranged for, all in just a few seconds in a crowded station.

AI technology has transformed Alibaba from just a humble "open sesame" for small enterprises to one of the most successful companies that is investing further to innovate and rewire the world.

In the United States, Apple rose to prominence with AI by targeting superior data security and unique user experiences.[2] Its machine learning algorithms run on devices instead of in the cloud, thus both preserving user privacy and enhancing edge computing capabilities of the devices. Its pioneering speech recognition system, Siri, combines state-of-the-art natural language processing (NLP) with AI to decipher nuanced conversation. Its tremendous success prompted several IT giants like Amazon (Alexa) and Google (Duplex) to follow suit.

Google is another of the few companies that has the technology work for it in a versatile fashion. Its search engine displays mastery over NLP. It is designed such that every typed word is linked to the words that it is commonly used with rather than just its meaning independently, and over time the machine

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Douglas Heaven, "The world's most prolific writer is a Chinese algorithm," *BBC Future – In Depth: Artificial Intelligence*, August 29, 2018, https://www.bbc.com/future/article/20180829-the-worlds-most-prolific-writer-is-a-chinese-algorithm.
Bernard Marr, "The Amazing Ways Chinese Tech Giant Alibaba Uses Artificial Intelligence And Machine Learning," *Forbes: Enterprise Tech*, July 23, 2018, https://www.forbes.com/sites/bernardmarr/2018/07/23/the-amazing-ways-chinese-tech-giant-alibaba-uses-artificial-intelligence-and-machine-learning/.
Will Knight, "Inside the Chinese lab that plans to rewire the world with AI," *MIT Technology Review*, March 7, 2018, https://www.technologyreview.com/2018/03/07/144875/inside-the-chinese-lab-that-plans-to-rewire-the-world-with-ai/.
Jack Ma, "The China Boom Project," interview by Orville Schell, *Asia Society*, March 12, 2009, transcript and mp4, https://doi.org/doi:10.7282/T3GQ6WKB.

2 Apple, *Developer documentation – Framework: Core ML Overview*, https://developer.apple.com/documentation/coreml.
Mohanbir Sawhney, "Why Apple And Microsoft Are Moving AI To The Edge," *Forbes*, January 27, 2020, https://www.forbes.com/sites/mohanbirsawhney/2020/01/27/why-apple-and-microsoft-are-moving-ai-to-the-edge/.
Leo Sun, "Apple is Quietly Expanding its Artificial Intelligence Ecosystem," *The Motley Fool*, January 23, 2020, https://www.fool.com/investing/2020/01/23/apple-is-quietly-expanding-its-artificial-intellig.aspx.
Alan Boyle, Taylor Soper, and Todd Bishop, "Apple acquires Xnor.ai, edge AI spin-out from Paul Allen's AI2, for price in $200M range," *GeekWire*, January 15, 2020, https://www.geekwire.com/2020/exclusive-apple-acquires-xnor-ai-edge-ai-spin-paul-allens-ai2-price-200m-range/.
Jordan Novet, "Apple's A.I. strategy stands apart from the rest of big tech, for better or worse," *CNBC*, June 13, 2018, Enterprise, https://www.cnbc.com/2018/06/13/apples-ai-strategy-devices-not-cloud.html.

learns intricate universal language structures that can predict a user's thought process quite accurately.[3] Google's deep learning algorithms for lung cancer detection in CT scans outperformed not one but six human radiologists.[4] Its deep neural networks recognize sounds to create subtitles for videos; its machine learning translates languages accurately and even transmits directly into its Pixel Bud headphones.[5]

Apart from the fun consumer technology innovations, AI has also led to a world of public good. Predictive analytics on weather patterns are minimizing crop losses, and robotics from PrecisionHawk and Iron Ox are paving the way for lean operations in agriculture amid labor shortage crises.[6] Image recognition technology has aided in finding missing persons, searching records for trafficking victims, and identifying unknown soldiers in war photographs. AI has even been helpful in investigating crime, diagnosing rare and genetic diseases

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3 Danny Sullivan, "FAQ: All about the Google RankBrain algorithm," *Search Engine Land*, June 23, 2016, https://searchengineland.com/faq-all-about-the-new-google-rankbrain-algorithm-234440.

4 Khari Johnson, "Google's lung cancer detection AI outperforms 6 human radiologists," *Venture Beat*, May 20, 2019, https://venturebeat.com/2019/05/20/googles-lung-cancer-detection-ai-outperforms-6-human-radiologists/.
Jeffrey De Fauw et al., "Clinically applicable deep learning for diagnosis and referral in retinal disease," *Nature Medicine* 24 (September 2018): 1342-1350, https://doi.org/10.1038/s41591-018-0107-6.

5 Jeff Dean and Andrew Ng, "Using large-scale brain simulations for machine learning and A.I.," *AI – Research* (blog), Google, June 26, 2012, https://googleblog.blogspot.com/2012/06/using-large-scale-brain-simulations-for.html.
Sourish Chaudhuri, "Adding Sound Effect Information to YouTube Captions," *Google AI Blog* (blog), Google AI, March 23, 2017, https://ai.googleblog.com/2017/03/adding-sound-effect-information-to.html.
Jon Porter, "The Pixel Buds' translation feature is coming to all headphones with Google Assistant," *Circuit Breaker*, October 15, 2018, https://www.theverge.com/circuitbreaker/2018/10/15/17978298/pixel-buds-google-translate-google-assistant-headphones.

6 James Vincent, "Robot farming startup Iron Ox has started selling its produce in California," *The Verge*, May 2, 2019, https://www.theverge.com/2019/5/2/18526590/robot-farming-startup-iron-ox-california-leafy-green-bianchinis.
"The Smarter Farming Package by PrecisionHawk and DJI," YouTube video, 2:01, May 3, 2016, https://youtu.be/i3_8JIme8lU.
J. Mark Munoz, "AI in Agriculture: Is the Grass Greener?," *CMR Insights: Frontier*, March 30, 2020, https://cmr.berkeley.edu/2020/03/ai-agriculture/.
Tanya M. Anandan, "Cultivating Robotics and AI for Sustainable Agriculture," *Robotics Industries Association: Industry Insights*, July 22, 2019, https://www.robotics.org/content-detail.cfm/Industrial-Robotics-Industry-Insights/Cultivating-Robotics-and-AI-for-Sustainable-Agriculture/content_id/8195.

through imaging, and even revolutionizing financial services transactions in emerging economies where creditworthiness is hard to prove.[7]

However, the technology is fueled by data and these solutions can magnify the biases inherent in that data and project them into the future — especially in high stakes areas such as the criminal justice system, social media, and hiring.[8] Let's dig deeper into this and numerous other hurdles that firms need to overcome if attempting to implement the technology. ■

Challenges That Can Derail

For any emerging technology to bring value to an organization, its implementation has to be supported by both organizational and technological capabilities. Here we outline AI-specific challenges in these two critical areas.

ORGANIZATIONAL CHALLENGES

• STRATEGY

Each of the following questions needs a clear answer for a robust AI strategy: Why should AI be a priority for my business? Would it offer me any long-term competitive advantage? What is the exact problem I should be addressing? What do success criteria look like and how can they be quantified? How can

7 Brad Smith, "Facial recognition: It's time for action," *Microsoft On the Issues* (blog), *Microsoft*, December 6, 2018, https://blogs.microsoft.com/on-the-issues/2018/12/06/facial-recognition-its-time-for-action/.
AWS, *Amazon Rekognition: Developer Guide*, https://docs.aws.amazon.com/rekognition/latest/dg/considerations-public-safety-use-cases.html.
AWS, *Amazon Rekognition Customers*, https://aws.amazon.com/rekognition/customers/.
Ry Crist, "Amazon's Rekognition software lets cops track faces: Here's what you need to know," *CNET*, March 19, 2019, https://www.cnet.com/news/what-is-amazon-rekognition-facial-recognition-software/.

8 Derek Thompson, "Should We Be Afraid of AI in the Criminal-Justice System?," *The Atlantic: The Presence of Justice*, June 20, 2019, https://www.theatlantic.com/ideas/archive/2019/06/should-we-be-afraid-of-ai-in-the-criminal-justice-system/592084/.

it be operationalized and which risks can be best mitigated? Do managers even have sufficient AI and data literacy? How do we weave in an effective and robust data strategy that accounts for the necessary legal and ethical issues? This gets tricky very quickly for multinational firms since privacy laws differ from country to country.

• LEADERSHIP VISION

Organizational leadership that cannot envision and define a transformed end state could not only slow down adoption of AI, but also potentially be a barrier to improving solutions. Given the technology's potential for wide-ranging impact, a lack of vision can lead to amplified failures. Further, the hierarchy of decision-making and information flow can be complex in large organizations, leading to a lack of alignment on the technology's potential or organizational capabilities. If risk appetite is unequal among functional leadership, conviction levels toward leveraging AI will also be unequal.

Managers, instead of championing the technology, could end up posing a barrier to adoption.

• TALENT GAP

Designing AI solutions requires bilinguals: those who can speak both technology and business languages. Proliferating data science courses are quickly filling in this talent gap, so the challenge now is helping the data scientists understand business parlance. On the other hand, subject matter experts (SMEs) in business functions don't necessarily understand how AI can transform their businesses. When there is a gap in perception between technology and business functions, managers, instead of championing the technology, could end up posing a barrier to adoption.

• BUDGET

The financial cost of developing, deploying, and maintaining an AI solution is often very high. The infrastructure needed for the build and deployment will involve handsome capital expenditures (Capex) and operating expenses (Opex) for storage, networking, data needs, and the necessary adjacent technologies.[9] Note that Opex too can create substantial strain, especially for continued data management since the strength of ML derives from continued data feed and analysis. Although cloud solutions are available for containing infrastructure costs while scaling, they pose privacy and security challenges.

TECHNOLOGICAL CHALLENGES

• DATA

Volume, velocity, and veracity are the often-cited terms to describe the needs of big data. ML's power lies in recognizing signal from noise, and the greater the volume of data, the better the results. Also, new insights will require new data so ML will require a constant and voluminous data flow. But just any data will not do; high-quality data that's accurate and representative of the segments that are being analyzed is critical. AI has the potential to magnify human biases, so the quality of data fed determines the quality and credibility of the predicted output.[10] Firms often find that ensuring a continued flow of relevant and representative data, over time, can be quite a challenge.

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9 Bob Violino, "Designing and building artificial intelligence infrastructure," *TechTarget: SearchEnterpriseAI*, April 5, 2018, https://searchenterpriseai.techtarget.com/feature/Designing-and-building-artificial-intelligence-infrastructure.

10 Kyle Wiggers, "Amazon's Rekognition misidentified 28 members of Congress as criminals," *Venture Beat*, July 26, 2018, https://venturebeat.com/2018/07/26/amazons-rekognition-misidentified-28-members-of-congress-as-criminals/.
Jackie Snow, "Google Photos Still Has a Problem with Gorillas," *MIT Technology Review*, January 11, 2018, https://www.technologyreview.com/2018/01/11/146257/google-photos-still-has-a-problem-with-gorillas/.
"Google apologises for Photos app's racist blunder," *BBC News: Tech*, July 1, 2015, https://www.bbc.com/news/technology-33347866.

• SECURITY

Cybersecurity threats continuously loom with AI. For instance, AI is more effective for securing passwords to ward off the brute-force method that hackers use, but what if the hackers themselves use AI-powered attacks?[11] Adding a further layer of complexity is the fast-evolving nature of the technology. Traditional cybersecurity tools are falling short of detecting modern fraudsters that use spoofed voices, commercial voice-generating software, or even stitched audio samples that are publicly available.[12] Proofing applications can be developed to battle this but the challenge is that the solutions have to be as dynamic as the technology, and probably even a notch ahead.[13]

• PRIVACY

Unlike passwords, biometrics, once leaked, are unchangeable, and if irretrievable, remain a threat for the rest of the person's life.[14] When data is mined and

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11 Yi Xu et al., "Virtual U: Defeating Face Liveness Detection by Building Virtual Models from Your Public Photos," *25th USENIX Security Symposium*, August 10-12, 2016, https://www.usenix.org/conference/usenixsecurity16/technical-sessions/presentation/xu.
Adam Janofsky, "AI Could Make Cyberattacks More Dangerous, Harder to Detect," *Wall Street Journal*, November 13, 2018, https://www.wsj.com/articles/ai-could-make-cyberattacks-more-dangerous-harder-to-detect-1542128667?mod=article_inline.
Jeff John Roberts, "Airport and Payment Facial Recognition Systems Fooled by Masks and Photos, Raising Security Concerns," *Fortune: Tech: Facial Recognition*, December 12, 2019, https://fortune.com/2019/12/12/airport-bank-facial-recognition-systems-fooled/.
Lily Hay Newman, "Hackers Trick Facial-Recognition Logins With Photos From Facebook (What Else?)," *WIRED: Security*, August 19, 2016, https://www.wired.com/2016/08/hackers-trick-facial-recognition-logins-photos-facebook-thanks-zuck/.

12 United Nations Interregional Crime and Justice Research Institute (UNICRI) and The International Criminal Police Organization (INTERPOL), *TOWARDS RESPONSIBLE AI INNOVATION: SECOND INTERPOL-UNICRI REPORT ON ARTIFICIAL INTELLIGENCE FOR LAW ENFORCEMENT*, May 2020, http://213.254.5.198/towards-responsible-artificial-intelligence-innovation.
Catherine Stupp, "Fraudsters Used AI to Mimic CEO's Voice in Unusual Cybercrime Case," *Wall Street Journal*, August 30, 2019, https://www.wsj.com/articles/fraudsters-use-ai-to-mimic-ceos-voice-in-unusual-cybercrime-case-11567157402.

13 Simon Brandon, "How to catch a criminal using only milliseconds of audio," *World Economic Forum*, January 10, 2018, https://www.weforum.org/agenda/2018/01/catch-criminal-milliseconds-audio-rita-singh-carnegie/.

14 Andy Greenberg, "OPM Now Admits 5.6m Feds' Fingerprints Were Stolen By Hackers," *WIRED: Security*, September 23, 2015, https://www.wired.com/2015/09/opm-now-admits-5-6m-feds-fingerprints-stolen-hackers/.

put to use in high-stakes applications such as law enforcement, the potential for negative consequences goes up exponentially.[15] Ethics and responsibility of AI have to hence be clearly defined in the firm's AI strategy. This all gets even trickier as multinational firms navigate privacy laws that differ across countries.

Successful use cases of AI show that having a vision, clarifying the objective of what and why to stakeholders, bringing required skill sets together, and putting in place technological requirements such as data and IT infrastructure are keys to success. We'll discuss this in this paper, but first, a quick note on what AI cannot do, yet. ■

What Can AI Not Do, Yet?

The answer: Be a human. AI is typically classified under two domains: artificial general intelligence (AGI), referred to as strong AI, and artificial narrow intelligence (ANI), called weak AI. Weak AI works only in the particular application it was designed for. Strong AI can apply its knowledge elsewhere, make its own plans based on its experiences, have independent consciousness, and adapt to changing environment.[16] The spectrum of AI applications that we see today, ranging from simple manufacturing automation to advanced machine learning applications that far surpass human abilities, lies between ANI and AGI.

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15 Thomas Brewster, "These Ex-Spies Are Harvesting Facebook Photos For A Massive Facial Recognition Database," *Forbes*, April 16, 2018, https://www.forbes.com/sites/thomasbrewster/2018/04/16/huge-facebook-facial-recognition-database-built-by-ex-israeli-spies/. An Israeli firm, Terrogence (owned by Verint), has been building a facial recognition database from Facebook and other social media. Harvesting publicly available images for surveillance and spying raises potential negative consequences, especially in the case of Verint, which is a vendor to the U.S. govt. and misidentification can lead to misjudgments.

16 Kathleen Walch and Ronald Schmelzer, "Weak, Strong AI – Do these Terms Matter?," in *AI Today Podcast*, podcast, 15:08, https://www.cognilytica.com/2017/10/25/ai-today-podcast-008-weak-strong-ai-terms-matter/. J Matthew Helm et al., "Machine Learning and Artificial Intelligence: Definitions, Applications, and Future Directions," *Current Reviews in Musculoskeletal Medicine* 13, no. 1 (2020): 69-76, https://doi.org/10.1007/s12178-020-09600-8.

At the extreme end of strong AI is the ultimate robot that might take over the human race (think: Agent Smith from *The Matrix*), and we are nowhere close to approaching that level of strength in our AI designs. Even the less worrisome AI designs in the movies *Ex Machina* and *her*, which are able to experience consciousness like humans, are just fiction.

Robots can, however, take over some human roles and render many jobless. That's where managerial creativity comes into play. The problem has to be viewed as a reason to create alternative opportunities and create adjacencies and expand organizational capabilities for further innovations, while avoiding a few expensive pitfalls. ■

AI TERMINOLOGY

Artificial intelligence (AI) has many definitions, but fundamentally they all refer to machines that are capable of thinking like humans or, arguably, with above human intelligence.[17] Terms like machine learning (ML), deep learning (DL), and predictive analytics are all subsets of AI, using past data to predict the future. For detailed explanations of such AI terms, please see **Glossary: Understanding AI Terminology** on page 34.

17 Bernard Marr, "The Key Definitions Of Artificial Intelligence (AI) That Explain Its Importance," *Forbes: Enterprise Tech*, February 14, 2018, https://www.forbes.com/sites/bernardmarr/2018/02/14/the-key-definitions-of-artificial-intelligence-ai-that-explain-its-importance/.
Stefano A. Bini, "Artificial Intelligence, Machine Learning, Deep Learning, and Cognitive Computing: What Do These Terms Mean and How Will They Impact Health Care?," *The Journal of Arthroplasty* 33, no. 8 (2018): 2358-2361, https://doi.org/10.1016/j.arth.2018.02.067.

7 Key Pitfalls to Avoid

We've identified seven key AI pitfalls, along with the ways that companies are addressing and, even better, sidestepping them altogether. Three key areas that decision-makers need to actively address are managing stakeholder perceptions, prioritizing incremental improvements while keeping transformative innovations in mind, and evaluating value propositions and risks before implementation.

PITFALL #1: THINKING ROBOTS WILL REPLACE HUMANS RATHER THAN AUGMENT HUMAN ABILITIES.

AI systems (and in fact, almost all new technologies) increase productivity and sometimes replace labor. However, AI cannot completely eliminate humans. Henn-na Hotel in Nagasaki, Japan, had 243 robots serving customers until the machines' inflexibility, and need for humans to help when they'd often get stuck, made the labor-cost-saving proposition infeasible.[18]

Leverage AI to first assist employees instead of replacing them; then, as a logical next step, encourage and motivate employees to engage with the new technology, making way for "human-machine" collaboration.[19] Many manual-labor-heavy firms are having AI work alongside humans instead of replacing them, such as Radial in e-commerce and Mercedes in production factories.[20]

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18 Alastair Gale and Takashi Mochizuki, "Robot Hotel Loses Love for Robots," *Wall Street Journal*, January 14, 2019, https://www.wsj.com/articles/robot-hotel-loses-love-for-robots-11547484628.

19 H. James Wilson and Paul R. Daugherty, "Creating the Symbiotic AI Workforce of the Future," *MIT Sloan Management Review: Frontiers*, October 21, 2019, https://sloanreview.mit.edu/article/creating-the-symbiotic-ai-workforce-of-the-future/.

20 Radial, "Radial Opens New Fulfillment Center in Locust Grove, Georgia" *PRNewswire*, October 6, 2020, https://www.prnewswire.com/news-releases/radial-opens-new-fulfillment-center-in-locust-grove-georgia-announces-full-time-hiring-needs-and-plans-to-hire-more-than-1-000-seasonal-fulfillment-jobs-to-support-upcoming-holiday-rush-301145960.html.
Tim Denman and Jamie Grill-Goodman, "The AI-Driven Supply Chain: Seamlessly Meeting Complex Demand," *Radial*, https://www.radial.com/sites/default/files/AI-Supply-Chain.pdf.

Diagnostic radiology is being augmented by AI to analyze unfathomable, large data sets from imaging equipment. This will not replace radiologists, but instead improve their ability to diagnose and advance clinical decisions.[21]

The problem of displacement, however, cannot be avoided in some cases. Such organizations have to strategize to enter adjacent markets to create additional opportunities for the employees who will be displaced. Boxed automated its retail fulfillment center and retrained the displaced workers as trainers and customer service agents. Similarly, Marlin Steel pivoted to robotic machines in its factory, but instead of cutting workforce, created new contracts with Boeing and GM for the high-quality precision products it was producing, and hired more.[22] Strategically balancing the changing skill sets in different functions and business units will be key for keeping up stakeholder responsibility.

PITFALL #2: ASSUMING EVERYONE — EMPLOYEES, CUSTOMERS, AND REGULATORS — WILL AUTOMATICALLY UNDERSTAND THE BENEFITS OF AI.

Stakeholders across the firm's value chain might not understand the benefits of AI the same way as the team at the headquarters would, but alignment is paramount for successful implementation of a highly misunderstood technology like AI.[23] For example, for a clinician to accept the efficacy of an ML model for diagnostics, she needs to be educated on the function and reasoning behind the model.

H. James Wilson and Paul R. Daugherty, "Collaborative Intelligence: Humans and AI Are Joining Forces," *Harvard Business Review*, July-August 2018, https://hbr.org/2018/07/collaborative-intelligence-humans-and-ai-are-joining-forces.

21 Jessica Kent, "How Artificial Intelligence is Changing Radiology, Pathology," *Health IT Analytics*, August 3, 2018, https://healthitanalytics.com/news/how-artificial-intelligence-is-changing-radiology-pathology.

22 Alston Ghafourifar, "Automation replaced 800,000 workers… then created 3.5 million new jobs," *VentureBeat*, September 7, 2017, https://venturebeat.com/2017/09/07/automation-replaced-800000-workers-then-created-3-5-million-new-jobs/.

23 Rahul Kapoor and Thomas Klueter, "Organizing for New Technologies," *MIT Sloan Management Review* 58, no. 2 (Winter 2017): 85-86, https://sloanreview.mit.edu/article/organizing-for-new-technologies/.

Internally, firms can take proactive measures by involving employees during ideation, encouraging creativity for workable innovations, establishing trust with employees by being transparent about the implementation of AI, and alleviating their fears by establishing the human-machine collaboration. Also, investing in reskilling employees will help in agility, collaboration for data, and ease of implementation across functions. PlainsCapital Bank in Texas created an integrated role, universal banker, to meet increasing demand for digital banking.[24] And instead of firing the displaced employees, it trained them in both technical and socioemotional skills to prepare them for the new role.

> Alignment is paramount for successful implementation of a highly misunderstood technology like AI.

When it comes to external stakeholders, although most companies will proudly announce their use of AI technology, only a few effectively communicate the value beyond simply a signal of their technological investment into new and emerging fields. Domino's Pizza did this well by showcasing quantifiable benefits such as increasing order readiness predictions from 75 percent to 95 percent from AI-based solutions developed in a strategic partnership with Nvidia. This helped boost its market value significantly.[25]

To meet regulatory requirements, welcoming oversight from and following guidelines of agencies such as the Organization for Economic and Cooperation Development (OECD) and the World Economic Forum (WEF) are

24 Eva Sage-Gavin, Madhu Vazirani, and Francis Hintermann, "Getting Your Employees Ready for Work in the Age of AI," *MIT Sloan Management Review: Frontiers*, February 27, 2019, https://sloanreview.mit.edu/article/getting-your-employees-ready-for-work-in-the-age-of-ai/.

25 In July 2020, Domino's had a price to earnings ratio of 47, which is nearly twice that of its competitors such as Pizza Hut (~25x P/E): Rick Merritt, "Life of Pie: How AI Delivers at Domino's," *The NVIDIA Blog* (blog), NVIDIA, January 13, 2020, https://blogs.nvidia.com/blog/2020/01/13/dominos-pizza-ai/.
Simply Wall St, *Is Domino's Pizza, Inc.'s (NYSE:DPZ) High P/E Ratio A Problem For Investors?*, January 11, 2020, https://simplywall.st/stocks/us/consumer-services/nyse-dpz/dominos-pizza/news/is-dominos-pizza-inc-s-nysedpz-high-p-e-ratio-a-problem-for-investors-2.

beneficial and address concerns of privacy and security.[26] Having a formal AI governance structure in place can make sure ethics are not compromised in building AI solutions, thus building credibility with stakeholders.

PITFALL #3: LIMITING AI TO ONLY INCREMENTAL IMPROVEMENTS RATHER THAN EXPLORING ITS TRANSFORMATIVE POTENTIAL.

The easiest option to experiment with the technology is on incremental improvements, the most common of which are cost efficiencies and/or process automations.[27] Although aiming for such quick wins is good for early adoption, it's important not to get lost in myopic possibilities, limiting oneself to tactical solutions rather than strategic and transformative ones.

A relatable example is automating workflows in a clinical setting, which can surely boost clinician productivity in examining patients, resulting in higher revenues for providers.[28] However, the true transformative potential of AI lies in precision medicine and surgery, improved clinical trial results, image quality reduction and reconstruction, and more. To gain competitive advantage, an organization should aim at the technology's larger potential, lest it be lost in the weeds of marginal improvements.

The approach to move from process automation to reinvention involves 1) reimagining processes from scratch, 2) capturing the exponential power of dark data (data that organizations collect but don't use), and 3) unlocking the

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26 Alex Castrounis, "How to Set AI Goals," *O'Reilly: Radar*, September 15, 2020, https://www.oreilly.com/radar/how-to-set-ai-goals/.
KPMG, *Living in an AI World 2020 study: Achievements and challenges of artificial intelligence across five industries*, 2020, https://advisory.kpmg.us/content/dam/advisory/en/pdfs/2020/living-in-ai-world.pdf.

27 Deloitte, *Global Cost Report: Save-to-transform as a catalyst for embracing digital disruption*, 2019-2020, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/process-and-operations/us-global-cost-survey-2019.pdf. A survey by Deloitte found that the top reasons for applying cognitive and AI technologies is reducing cost.

28 Greg Freiherr, "Is Digitalization Driving Innovation or Innovation Digitalization?," *Siemens Healthineers*, November 26, 2019, https://www.siemens-healthineers.com/en-us/news/mso-digitalization-and-innovation.html.

full potential of human-machine interaction.[29] Accenture found that using this three-pronged approach could double the probability of achieving a tenfold improvement in key performance indicators (KPIs).

After using smart machines to focus on airplane maintenance for years, GE progressed to using predictive analytics to replace the existing processes and drive greater improvements. It now makes real-time predictions on which engines should be fixed and by what kind of technician, thus unlocking the full potential for human-machine interaction.[30]

When radical innovations seem like moon shots, organizations can explore reimagining work processes instead of limiting themselves to automation. Quick wins and case studies can provide the required motivation among teams to identify use cases that can benefit with more advanced AI solutions.

PITFALL #4: STRIVING FOR THE SHINIEST ALGORITHM RATHER THAN AIMING FOR IMPACT.

While transformation has to be the vision, falling for the allure of perfectionism can create high opportunity costs. A classic case is IBM's Watson for Oncology, which took years to take off because feeding massive amounts of diagnostic data about all cancers was a gigantic task, and interpreting handwritten doctor notes and acronyms complicated it further; when finally launched, its treatment recommendations weren't efficacious outside the U.S. since both prevalence and treatments of cancers differ dramatically globally.[31] To avoid disastrous and expensive results, goals should be bite-size and

29 Paul Daugherty and H. James Wilson, "Process Reimagined: Together, people and AI are reinventing business processes from the ground up," *Accenture Research*, 2018, https://www.accenture.com/_acnmedia/PDF-76/Accenture-Process-Reimagined.pdf#zoom=50.

30 Daugherty and Wilson, "Process Reimagined," 2018.

31 Thomas C. Redman, "If Your Data Is Bad, Your Machine Learning Tools Are Useless," *Harvard Business Review*, April 2, 2018, https://hbr.org/2018/04/if-your-data-is-bad-your-machine-learning-tools-are-useless.
Jeff Catlin, "How To Underwhelm With Artificial Intelligence," *Forbes: Forbes Technology Council*, March 20, 2018, https://www.forbes.com/sites/forbestechcouncil/2018/03/20/how-to-underwhelm-with-artificial-intelligence/.
Casey Ross and Ike Swetlitz, "IBM pitched its Watson supercomputer as a revolution in cancer care. It's nowhere close," *Stat News*, September 5, 2017, https://www.statnews.com/2017/09/05/watson-ibm-cancer/.

achievable. Prioritizing impact and scalability can help in striking a balance between aiming for the shiniest solution and settling for a lackluster design.

Similarly, a complex and uninterpretable solution is not necessarily better. There might be a simpler solution that's less dazzling but also less opaque and more impactful. Equivant's complex 137-variable model ML algorithm for estimating reoffences and setting criminal sentences was outperformed by a simple 2-variable linear model that was significantly faster and easier to implement and interpret.[32] Meanwhile, Equivant received bad press for its model's opaqueness.[33]

In complex operations, like those in the oil and gas industry, ingesting data from thousands of pieces of equipment into a single platform and scaling it across the entire operation can be a gigantic and almost impossible task.[34] Implementing and scaling AI solutions here will demand maturity of enabling technologies too. In such cases, firms prefer to aim for impact rather than seek perfection.[35] Exxon Mobil deployed an AI-enabled platform that accelerates project development, provides access to data from multi-cloud applications, quickens decision-making, and reduces the return-on-investment cycle.[36]

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32 Julia Dressel and Hany Farid, "The accuracy, fairness, and limits of predicting recidivism," *Science Advances* 4, no. 1 (2018), https://doi.org/10.1126/sciadv.aao5580.

33 Equivant's COMPAS (Correctional Offender Management Profiling for Alternative Sanctions) estimates the chance of a defendant reoffending and has been used by judges in several states for setting criminal sentences. Derek Thompson, "Should We Be Afraid of AI in the Criminal-Justice System?," *The Atlantic: The Presence of Justice*, June 20, 2019, https://www.theatlantic.com/ideas/archive/2019/06/should-we-be-afraid-of-ai-in-the-criminal-justice-system/592084/.
Julia Angwin et al., "Machine Bias," *ProPublica*, May 23, 2016, https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing.

34 Matthew V. Veazey, "AI Concerns Tied to Scalability, Complexity Assumptions," *Rigzone*, June 12, 2019, https://www.rigzone.com/news/ai_concerns_tied_to_scalability_complexity_assumptions-12-jun-2019-159055-article/.

35 Bernard Marr, "The Incredible Ways Shell Uses Artificial Intelligence To Help Transform The Oil And Gas Giant," *Forbes: Enterprise Tech*, January 18, 2019, https://www.forbes.com/sites/bernardmarr/2019/01/18/the-incredible-ways-shell-uses-artificial-intelligence-to-help-transform-the-oil-and-gas-giant/.

36 Barry Samria, "Oil & Gas: Operators Slow In Adopting Game-Changing AI," *Audere Partners*, March 9, 2020, https://auderepartners.com/2020/03/09/oil-gas-ai/.

Another solution is to deploy in a limited environment, giving the organization a chance to experiment, iterate, and solve before affecting operations on a larger scale. For example, Shell implemented an AI solution for precision drilling and controlling drilling equipment, with an aim to scale it eventually.[37] For successful firmwide adoption, expertise for implementing AI can be built over time through a cohesive data and cloud strategy, collaboration and sharing best practices, and dissemination of the learning across the organization.[38]

For such pilots, it's essential to focus on a core business area. If the pilot fails, the learning is still relevant and can be used for further experiments. And expanding a successful pilot can be quicker, offering greater competitive advantage.

PITFALL #5: IMPLEMENTING WITHOUT A CLEAR VALUE PROPOSITION.

Prioritize thorough evaluation of the solutions' value proposition over timeline for implementation. Else, it can cause greater damage than the lost opportunity of not implementing — like the expensive ~$1 billion biometric exit solution of the Department of Homeland Security (DHS) that flags travelers for scrutiny by comparing them with a biometric facial database. It was proven ineffective and the additional value it brings is questioned by DHS itself.[39]

Taking time to evaluate the value proposition to the customer and making sure the business case is clear will save many a resource.[40] This involves determining exactly what you are solving for and why, and the business driv-

37 Barry Samria, "Oil & Gas: Operators Slow," 2020.

38 Pam Sahota, "On the road to AI adoption, slow and steady wins the race," *Thoughts on Cloud: Cognitive* (blog), IBM, November 29, 2018, https://www.ibm.com/blogs/cloud-computing/2018/11/29/ai-adoption-slow-steady/.

39 Harrison Rudolph, Laura M. Moy, and Alvaro M. Bedoya, "Not Ready For Takeoff Face Scans At Airport Departure Gates," *Georgetown Law: Center on Privacy & Technology*, December 21, 2017, https://www.airportfacescans.com/.

40 Paul J.H. Schoemaker and V. Michael Mavaddat, "Scenario Planning for Disruptive Technologies," in *Wharton on Emerging Technologies*, ed. George S. Day and Paul J.H. Schoemaker with Robert E. Gunther (Hoboken, NJ: John Wiley & Sons Inc., 2000), chap. 10.

ers that foster success. Quantification of the success criteria while defining the use case is critical and so is evaluation of the organization's available resources and its ability to manage uncertainty.[41]

This also means that the value proposition better be in the core competence areas of the firm; straying will tend to frustrate employees and send confounding signals to the market about the direction of the firm, while also wasting resources including time.

Data and AI are still niche activities for most firms, and when venturing into non-core competence areas, incumbents tend to show signs of fatigue due to unmet expectations. Bayer, the German pharma company, humorously identified its habit of continuous piloting as a disease called "Pilotitis."[42]

PITFALL #6: JUMPING IN WITHOUT APPRAISING THE RISKS OF IRRESPONSIBLE AI.

Since machines "learn" from the data we feed them, if we give them biased data, they will learn the biases too and magnify the bias pattern in the data. The subsequent repercussions for incumbent firms can be very expensive and damage brand image considerably.

When used in the public domain, AI also becomes a social endeavor with reputational risks. Microsoft's Tay chatbot experiment is one example. In pursuit of conversational understanding, its ML and NLP internalized abusive language on Twitter and magnified it.[43] Similarly, many initial algorithms from

41 Rita Gunther McGrath, "A Real Options Logic for Initiating Technology Positioning Investments," *Academy of Management Review* 22, no. 4 (October 1997): 974-996, http://www.jstor.org/stable/259251.

42 Ulla Kruhse-Lehtonen and Dirk Hofmann, "How to Define and Execute Your Data and AI Strategy," *Harvard Data Science Review*, July 2020, https://doi.org/10.1162/99608f92.a010feeb.

43 Oscar Schwartz, "In 2016, Microsoft's Racist Chatbot Revealed the Dangers of Online Conversation," *Tech Talk: Artificial Intelligence: Machine Learning* (blog), *IEEE Spectrum*, November 25, 2019, https://spectrum.ieee.org/tech-talk/artificial-intelligence/machine-learning/in-2016-microsofts-racist-chatbot-revealed-the-dangers-of-online-conversation. Microsoft's engineers fed the algorithm with data from professional comedians and let it discover patterns of language through its interactions to emulate in subsequent conversations. Within hours of its release Tay tweeted more than 95,000 times, but a majority of the messages were racist and abusive. Microsoft

well-reputed firms such as Google and Apple magnified racial bias in the data fed to them.[44] Human bias is inherent in data sets, and firms should emphasize not having their machines learn this. When experimenting, firms should evaluate, to their best possible ability, the risks for the solution to go in unanticipated directions.

A further step to interpreting the solutions that ML churns out is understanding why the algorithm is giving these solutions. An AI-powered stock investment platform, K1, lost one investor ~$20 million daily, and the Artificial Intelligence Equity ETF (AIEQ) generated more losses than the S&P 500 index and sold some of the market's highest-winning stocks. Reason? They took stock positions based on the stocks themselves without assessing the value of the underlying businesses.[45] AI cannot necessarily take a long-term perspective and surely cannot replace the nuanced decision-making that involves human intuition and qualitative judgment factors.

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withdrew the bot immediately and relaunched a redesigned version, four years later, after building a more socially acceptable version that can defend itself from trolls.

44 Jackie Snow, "Google Photos Still Has a Problem with Gorillas," *MIT Technology Review*, January 11, 2018, https://www.technologyreview.com/2018/01/11/146257/google-photos-still-has-a-problem-with-gorillas/. Google's search image recognition system mislabeled an African American woman as a gorilla.
Corinne Reid, "Artificial Intelligence Will Do What We Ask. That's a Problem," *Quanta Magazine: Artificial Intelligence*, January 30, 2020, https://www.quantamagazine.org/artificial-intelligence-will-do-what-we-ask-thats-a-problem-20200130/. YouTube's algorithm recommended disturbing and conspiratorial content.
Jeffrey Dastin, "Amazon scraps secret AI recruiting tool that showed bias against women," *Reuters*, October 10, 2018, https://www.reuters.com/article/us-amazon-com-jobs-automation-insight/amazon-scraps-secret-ai-recruiting-tool-that-showed-bias-against-women-idUSKCN1MK08G. Amazon's AI-based recruiting engine recommended hiring predominantly white males.
Sridhar Natarajan and Shahien Nasiripour, "Viral Tweet About Apple Card Leads to Goldman Sachs Probe," *Bloomberg: Business*, November 9, 2019, https://www.bloomberg.com/news/articles/2019-11-09/viral-tweet-about-apple-card-leads-to-probe-into-goldman-sachs. Apple algorithms were revealed to have gender disparity when determining creditworthiness.

45 Thomas Beardsworth and Nishant Kumar, "Who to Sue When a Robot Loses Your Fortune," *Blomberg: Future Finance*, May 5, 2019, https://www.bloomberg.com/news/articles/2019-05-06/who-to-sue-when-a-robot-loses-your-fortune.
Keith Speights, "An AI-Powered ETF Failed Miserably at Beating the Market in 2018 -- Here's What You Can Learn From Its Mistakes," *The Motley Fool*, January 6, 2019, https://www.fool.com/investing/2019/01/06/an-ai-powered-etf-failed-miserably-at-beating-the.aspx.

Speaking to the often-cited conundrum of choosing interpretability over accuracy of a model (also called the black-box problem), experimenting with an uninterpretable algorithm is highly risky so it is better to exchange it for an interpretable albeit less accurate solution to avoid such disasters.[46] When applied to the criminal justice system, such mistakes make repercussions grave.[47] So understanding how the model behaves, validating the predictability of the model's output, and confirming whether the model's reasoning aligns with the stakeholder's mental model is critical.

Teams often work in silos but apply their models to have a large-scale effect instead, which makes it difficult to ensure that solutions are ethical and consistent with user expectations, organizational values, and societal norms. While it's not necessary to hire an expensive AI ethicist for this, it's imperative to have someone in the organization designated to ensure alignment with the bigger picture. AI governance structure informed by guidance from OECD or WEF, as mentioned in pitfall #2 above, can help in this endeavor.

PITFALL #7: THINKING "BIG DATA" MEANS "AI-READY."

It is fairly obvious that data requirements for AI are substantially greater than for any other analytics. Data must be known, understood, available, fit for purpose, and secure.[48] But if it's not representative enough for scaling, or the firm doesn't have sufficient capabilities for larger-scale implementation, the solutions might be limited to pilots and projects within existing silos.[49]

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46 Matt Turek, "Explainable Artificial Intelligence (XAI)," *Defense Advanced Research Projects Agency (DARPA): Our Research: Explainable Artificial Intelligence*, retrieved on December 18, 2020, https://www.darpa.mil/program/explainable-artificial-intelligence. The black box problem: The functions used in ML data models could be too complicated for humans to understand, and understandable functions often are less accurate.

47 Julia Angwin et al., "Machine Bias," *ProPublica*, May 23, 2016, https://www.propublica.org/article/machine-bias-risk-assessments-in-criminal-sentencing. Amazon's Rekognition software misidentified congressmen as criminals.

48 Michael Chui et al., "Notes from the AI frontier: Applications and value of deep learning," *McKinsey*, retrieved on December 1, 2020, https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-applications-and-value-of-deep-learning.

49 Michael Sadowski and Aaron Roth, "Technology Leadership Can Pay Off," *Research-Technology Management* 42, no. 3 (1999): 32-33, https://doi.org/10.1080/08956308.1999.11671315.

Firms like Google, Uber, and Tesla have sufficient and credible data to create and implement an AI solution for autonomous vehicles. But upon leaping into high-risk domains using AI such as self-driving cars, they ran into accidents, some of which were even lethal.[50] Despite their maturity in technological capabilities, they found it extremely difficult to build a fool-proof AI solution in certain areas.

In order to be AI-ready, first, firms need to take time building data quality fundamentals into their data strategy, maintain an audit trail for keeping a check on biases, and obtain an independent, rigorous quality assurance by either an internal quality assurance department or a reliable third party.[51]

Second, domain knowledge factors that are unique to the incumbent's business are to be considered to make a strong business case for AI. Straying from core competencies can be risky and wasteful.

Third, defining boundary conditions should be done before building capabilities within the organization, to both develop and implement solutions. Else, biting off more than one can chew can cause disastrous and expensive results, like in the case of IBM's Watson for Oncology. ■

50 Greg Bensinger and Tim Higgins, "Uber Suspends Driverless-Car Program After Pedestrian Is Killed," *Wall Street Journal*, March 20, 2018, https://www.wsj.com/articles/uber-suspends-driverless-car-program-after-pedestrian-is-killed-1521551002.
Jeff Catlin, "How To Underwhelm With Artificial Intelligence," *Forbes: Forbes Technology Council*, March 20, 2018, https://www.forbes.com/sites/forbestechcouncil/2018/03/20/how-to-underwhelm-with-artificial-intelligence/.

51 Thomas C. Redman, "If Your Data Is Bad, Your Machine Learning Tools Are Useless," *Harvard Business Review*, April 2, 2018, https://hbr.org/2018/04/if-your-data-is-bad-your-machine-learning-tools-are-useless.

A Framework for Gauging Adoption Readiness for AI

First mover advantages for incumbent firms are well-known, and so are their disadvantages and second-mover advantages, thus confirming incumbent inertia (reluctance to change).[52] But crossing the chasm and getting the mainstream market to adopt AI solutions will require adequate planning even before investing in the technology.[53] Since challenges such as security and scale discussed earlier can be magnified with large-scale operations in an incumbent's world, how can it evaluate whether, when, and how to adopt AI?

Here is a framework to indicatively gauge the firm's readiness for adoption while evaluating an AI use case.

Fundamentally, evaluating capabilities, both organizational and technological, will reveal the readiness of the organization to consider adopting AI in its business. A firm has to evaluate whether its capabilities allow it to build an AI solution or implement a solution built by someone else, or use some combination of the two to deliver a robust competitive response.[54]

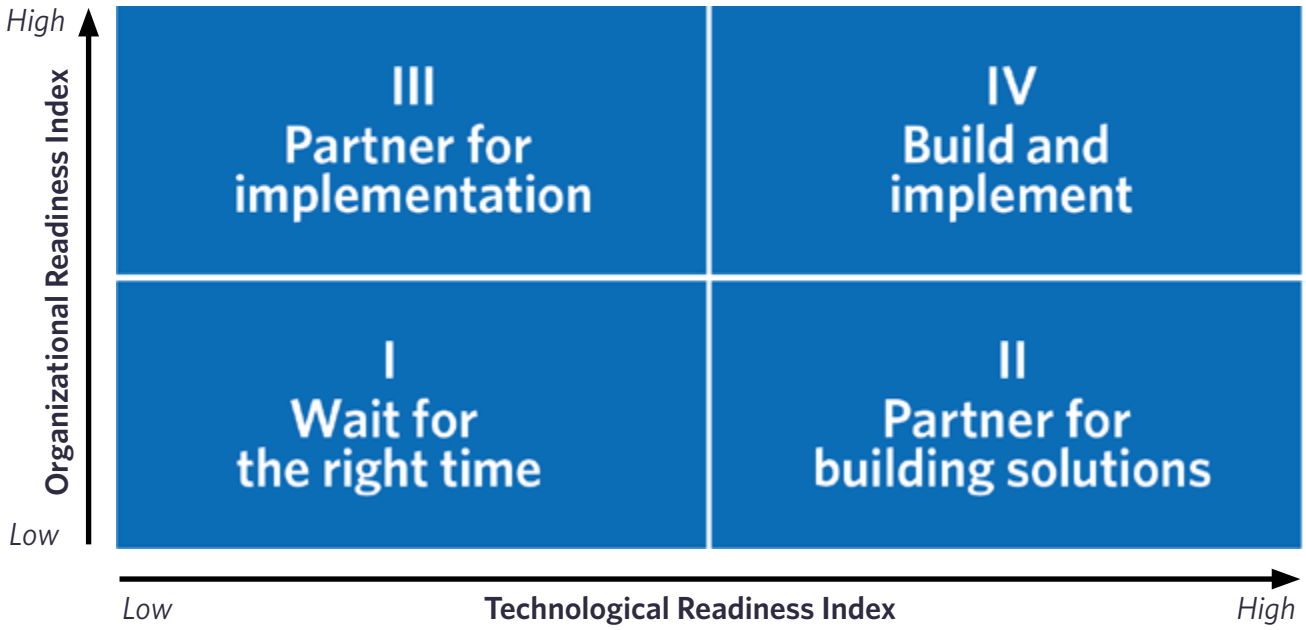
Although the figure shows quadrants here, organizational readiness and technological readiness have to be gauged on a spectrum of low to high.

52 Rajesh K. Chandy and Gerard J. Tellis, "The Incumbent's Curse? Incumbency, Size, and Radical Product Innovation," *Journal of Marketing* 64, no. 3 (July 2000): 1-17, http://www.jstor.org/stable/3203484.
Marvin B. Lieberman and David B. Montgomery, "First-mover (dis)advantages: Retrospective and link with the resource-based view," *Strategic Management Journal* 19, (1998): 1111-1125, http://marvinlieberman.com/wp-content/uploads/2016/08/fma2-smh1998.pdf.

53 Geoffrey A. Moore, *Crossing the Chasm* (New York, NY: Harper Business, 1991).

54 Christine Oliver, "Sustainable Competitive Advantage: Combining Institutional and Resource-Based Views," *Strategic Management Journal* 18, no. 9 (1997): 697-713, https://www.jstor.org/stable/3088134.

Gauging Adoption Readiness for AI



Technological Readiness Index TRI = f (Availability of data, Maturity of technology infrastructure, Maturity of enabling technologies

Organizational Readiness Index ORI = f (AI-enabling culture, Integration of business and technology, Established customer relationships)

Ultimately, the firm's risk appetite and the vision of its leadership will dictate its entry and adoption of AI.

INTERPRETATION OF THE MATRIX

• *A high technological readiness* — Quadrants II and IV — indicates the ability to build AI algorithms and create the right solutions.

• *A high organizational readiness* — Quadrants III and IV — indicates the ability to implement a created solution.

• *If high on both the TRI and ORI* — Quadrant IV — then the firm can build and implement AI solutions on its own.

Most incumbent firms fall in Quadrants II and III: ranking high/medium on one of the indices and low/medium on the other:

Q IV: Firms like Amazon or Google that are high on both the ORI and TRI can build AI solutions themselves and implement for their own businesses. But also, firms that are traditionally not high on the TRI are attempting to build their technology capabilities to protect their data; J.P. Morgan built its own AI platform, Omni AI.[55]

Q II: Firms like IBM that are high on the TRI but not as high on ORI factors such as established end-customer relationships can build AI solutions for other organizations that are high on the ORI for implementation. IBM Watson has partnered with Medtronic for personalized diabetes management solutions.[56]

Q III: Firms that are high on the ORI, but do not have the required technological readiness for building AI solutions, implement those built by others. Philips partnered with Path AI for precision

55 Martin Giles, "JPMorgan's CIO Has Championed A Data Platform That Turbocharges AI," *Forbes: CIO Network*, December 12, 2019, https://www.forbes.com/sites/martingiles/2019/12/12/jpmorgan-chase-ai-banking-model/.

56 Medtronic, *Medtronic And IBM Watson Health: Surfacing New Insights Together*, April 2019, https://www.medtronic.com/us-en/transforming-healthcare/aligning-value/collaboration-in-healthcare/leveraging-actionable-data/ibm-watson-sugar-iq.html.

diagnostics in cancer and Daimler with Nvidia for in-vehicle computing systems.[57]

Q I: A firm ranking medium on either or both indices can use its capabilities to support others in building or piloting AI solutions, and expect to integrate the learning over time and build the remaining capabilities required to create its own identity in the AI space.

Let's examine each of the factors in the indices.

Organizational Readiness Index (ORI)

A high level of organizational capabilities, indicated by an AI-enabling culture, the true integration of business and technology, and established customer relationships, determines organizational readiness for adoption of AI.

The foremost of requirements for measuring organizational readiness is an **AI-enabling culture**. In the context of ORI for AI, senior and middle management should be willing to entertain AI-based ideas, to stake resources for AI-related experiments, and to discuss and debate potential risks of adopting AI and strategize around it. Having one or more decision-makers as AI champions can not only further the culture within the organization but also convince skeptical external stakeholders.

Equally important is the willingness among junior management to embrace change. The most common threat that plagues junior-level staff is that of displacement; but existing employees can be sources of value and retraining them for transferability to other functions and business units can help gain greater buy-in.

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57 Royal Philips, *Philips and PathAI team up to improve breast cancer diagnosis using artificial intelligence technology in big data pathology research*, https://www.philips.com/a-w/about/news/archive/standard/news/press/2017/20170329-philips-and-pathai-team-up-to-improve-breast-cancer-diagnosis.html.
Mercedes-Benz AG and NVIDIA, *Mercedes-Benz and NVIDIA to Build Software-Defined Computing Architecture for Automated Driving Across Future Fleet*, June 23, 2020, https://media.mercedes-benz.it/download/881001/pi-mercedes-benz-nvidia-en.pdf.

Employees can be primed with proactive measures such as encouraging ideas for solving problems with AI at individual employee-level, incentivizing creativity and innovations, and establishing trust by being transparent about the implementation of AI.[58] Over time, when the organizational culture is molded deliberately by involving all levels of the organization in preparation for AI, cultural readiness will be seen in employees' enhanced risk appetite, openness to change, and willingness to learn and actively pursue creative ideas.[59]

A well-known example is Amazon, which went about actively probing every team on how they could embed the technology into their businesses. Over time the firm embedded AI in every function and business unit. Transformative product development through its own technology platform (AWS), seamless customer connectivity through Echo, and efficiency of inventory management through robots are illustrative of this.[60]

The secret sauce for success with AI is **true integration of business and technology** because AI has the potential to cause fundamental disruptions to business models. Silos block progress. People and processes that span boundaries, on the other hand, helpfully serve as anchors for knowledge sharing across functions and scaling the solutions. Bilinguals are important for AI enablement because they speak to both technological complexities of AI as well as business intricacies involved in its adoption. Processes that bridge the gap between business and technology groups and create incentives for working together can eliminate siloed functioning. This is critical in the long run for keeping pace with AI-enabled technology curves and for being able to spin

58 Michael Mankins, "How Leading Companies Build the Workforces They Need to Stay Ahead," *Harvard Business Review*, September 07, 2017, https://hbr.org/2017/09/how-leading-companies-build-theworkforces-they-need-to-stay-ahead.
https://medium.com/world-of-ai/leadership-in-ai-watch-moneyball-85125c81e54d

59 Marco Iansiti and Alan MacCormack, "Developing Products on Internet Time," *Harvard Business Review*, September-October 1997, https://hbr.org/1997/09/developing-products-on-internet-time.

60 https://www.wired.com/story/robotics-renaissance/
https://www.wired.com/story/amazon-artificial-intelligence-flywheel/

the advancements appropriately and in a timely fashion to take advantage of business environment changes.

Amazon illustrated this boundary spanning well by integrating business and technology functions for aggressively adopting AI. Its established processes such as the six-pager rule and strictly customer-centric innovations force business and technology functions to work with each other — all product and service proposals have to fit within six pages including a business case and a plan for technical product development; all proposed innovations have to be strictly customer-focused, which means ideas have to be built ground-up from the business teams.[61] It is this approach that fast-paced its innovations in AI and made Amazon a leader today even though it was far behind its competitors in AI adoption a few years ago.

After garnering enough knowledge through experimentation, Amazon established a team to serve as a knowledge hub that is dedicated to spreading AI into other parts of the company and helping all business units use ML models easily.

Established **customer relationships** are a fertile source for test pilots and give momentum to product launches.[62] Developing a differentiated value proposition is made easier when long-term established customer relationships are studied, and preferences understood.

Lego is well-known for its open innovation approach of soliciting ideas from its customers to build new products. In 2019, it developed an AI-powered software to translate traditional visual instructions to verbal/tactile Braille directions for the visually impaired.[63]

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61 https://www.wired.com/story/amazon-artificial-intelligence-flywheel/

62 Laurence Capron and Will Mitchell, "When to Build: Internal Development Versus External Sourcing," in *Build, Borrow, or Buy* (Boston, MA: Harvard Business Review Press, 2012), chap. 2.

63 https://legoaudioinstructions.com/
Lego launched Braille Bricks with studs on the top to reflect numbers and letters in the Braille alphabet to teach differently abled children. https://www.lego.com/en-gb/aboutus/discover/stories/audio-braille-instructions/
https://www.legobraillebricks.com/

The pilot was a huge success and subsequently Lego launched additional products such as Braille Bricks, leveraging its established brand equity.

Technological Readiness Index (TRI)

Technological readiness of the organization can be gauged by evaluating its data, infrastructure required to support AI, and the availability of enabling technologies for customer adoption of the AI-powered solution.

Existence of **data** is defined by both right volume and right quality that's domain-specific and timely. For example, designing an AI algorithm to identify causes of potential defects in manufacturing will require production data from different days and times of the day and from different machines and operators. Then again, maybe temperature fluctuations in the room and the machines are the factors influencing the output. Or maybe the raw materials sourced from different locations are inconsistent. Collecting data from different sources, sampling methodology, aggregating, and validating them is usually the biggest challenge in organizations.[64]

Incumbent firms, like GE, admit to collecting a lot of data but most of it sits in the dark and is unused, earning the title "dark data."[65] Firms have to identify and put their dark data to use. This can be done through partnerships like that of Netcetera and 4Quant, whose JV (AI First) helps revive the dark data to identify appropriate use cases.[66]

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https://www.forbes.com/sites/peterslatin/2019/08/28/lego-launches-web-site-with-ai-powered-text-instructions-its-second-pilot-for-the-blind-this-year/#5a2dc51d3924 https://www.forbes.com/sites/peterslatin/2019/05/01/legos-braille-bricks-arent-just-for-kids/#347168c743ad

64 Carlos Melendez, "Data is the lifeblood of AI, but how do you collect it?," *InfoWorld*, August 8, 2018, https://www.infoworld.com/article/3296044/data-is-the-lifeblood-of-ai-but-how-do-you-collect-it.html.

65 InsideBIGDATA, *Dark Data and the IIoT*, April 10, 2017, https://insidebigdata.com/2017/04/10/dark-data-iiot/.

66 Netcetera, *4Quant and Netcetera drive Artificial Intelligence: Joint venture AI First launched*, March 27, 2019, https://www.netcetera.com/home/stories/news/20190327-launch-aifirst.html.

Similarly, security and legality of usage of data, and a consistent data flow are some of the other essential factors.[67] The larger the data sets needed, such as in ML applications, the more magnified data challenges get, making data the topmost requirement for TRI.[68]

Maturity of **technological infrastructure** required for AI and its enabling technologies is critical for scaling AI solutions. For instance, White Ops is a cybersecurity firm that prevents fraudulent online advertising[69] by detecting whether impressions are generated by humans or bots. Its algorithm analyzes thousands of data points across trillions of transactions to predict malicious behavior, accurately. For a quick response to an attack, it requires infrastructure to process 150 billion transactions a day with 10-millisecond latencies, and needs to have enough elasticity to scale up and down during peaks and downtimes to redirect resources for product development.

Note that with AI also the traditional IT network, data, and computing infrastructure are required, but they all have to be AI-specific to be able to handle petabytes and exabytes (1,024 terabytes and 1,024 petabytes) of data storage and also process at very low latencies. Many incumbent firms do not have this kind of infrastructure today, or if they do, the infrastructure exists in a discrete fashion and is not synthesized internally for AI. However, firms can obtain this infrastructure from mature computing infrastructure providers such as AWS, Google, IBM, Microsoft, Nvidia, Lenovo, Tencent, etc., which enable the preparation of data, model building, model validation, and deployment at scale, and even support low latencies for edge computing.[70]

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67 Willem Sundbald, "Data Is The Foundation For Artificial Intelligence And Machine Learning," *Forbes: Manufacturing*, October 18, 2018, https://www.forbes.com/sites/willemsundbladeurope/2018/10/18/data-is-the-foundation-for-artificial-intelligence-and-machine-learning/.

68 Benjamin Biering, "Getting Started With AI: How Much Data Do You Need?," *2021.AI*, January 2020, https://2021.ai/getting-started-ai-how-much-data-needed/.

69 AWS, *White Ops Uses AWS to Help Customers Stop Ad Fraud*, https://aws.amazon.com/solutions/case-studies/whiteops/.

70 Forrester, *Now Tech: AI Infrastructure, Q1 2020*, February 7, 2020, https://www.forrester.com/report/Now+Tech+AI+Infrastructure+Q1+2020/-/E-RES155777.
George S. Day and Paul J. H. Schoemaker, "A Different Game," in *Wharton on Emerging Technologies*, chap. 1.

Equally important for gauging technological readiness are **enabling technologies**. In some cases, they are critical for successful AI solutions to be built and implemented.[71]

A simple example is imaging technologies, where imaging equipment itself has to be mature enough for ML algorithms to work on them. Image quality transfer (IQT) is an imaging technique that uses ML to transfer rich-quality information from one-off medical imaging devices to corresponding abundant-but-low-quality images in resource-poor locations. Once the mappings are learned the procedure can be used to map low-quality images to the corresponding high-quality ones.[72] The learning is also generalizable when the training data set does not directly represent the application domain. Here, the imaging equipment is a critical enabling technology to gather data and support the ML algorithm.

The Engineering and Physical Sciences Research Council (EPSRC) is using this IQT approach to map MRI scanning images from the U.K. with those from Nigeria for childhood epilepsy.[73] Since matched pairs of images from the same subjects in the U.K. and Nigeria are often hard to obtain from a sub-Saharan city hospital in Nigeria, ML algorithms are used to construct image-to-image mappings without directly matching training data.

Marquis Cabrera, "Use co-opetition to build new lines of revenue," *Harvard Business Review*, February 10, 2014, https://hbr.org/2014/02/use-co-opetition-to-build-new-lines-of-revenue.
Predictive Analytics Today ReviewDesk, "Top 18 Artificial Intelligence Platforms," *PAT Research*, retrieved on December 1, 2020, https://www.predictiveanalyticstoday.com/artificial-intelligence-platforms/.

71 Vijay Gadepally et al., "AI Enabling Technologies: A Survey," *ArXiv* (2019), https://arxiv.org/abs/1905.03592.

72 Daniel C. Alexander, "Image quality transfer and applications in diffusion MRI," *NeuroImage* 152, no. 15 (2017): 283-298, https://doi.org/10.1016/j.neuroimage.2017.02.089.
University College London, *Enabling technology portfolio*, retrieved on December 18, 2020, https://www.ucl.ac.uk/intelligent-imaging-healthcare/about/enabling-technology-portfolio.

73 Daniel Alexander, *Enabling Clinical Decisions From Low-power MRI In Developing Nations Through Image Quality Transfer*, University College London, https://gtr.ukri.org/projects?ref=EP/R014019/1.

Similarly, although robotic actuation in laparoscopic surgeries are available, they are largely underutilized because of a lack of 3D capabilities to interpret the images.[74]

Other key technologies worth noting are graphical processing units (GPUs) that can provide sufficient computing power for iterative processing, the internet of things (IoT) that generates massive amounts of data to and from connected devices, edge computing technology, drones, sensors, semiconductors, 3D printers, advanced ML algorithms, and application programming interfaces (APIs) that help add AI functionalities to existing products.[75]

Often, the TRI factors — data, enabling technologies, and sometimes AI infrastructure too — exist in an incumbent organization, but they are discrete and disconnected from one another. If an incumbent has them, it should determine their maturity and be able to manage them such that they are integrated and go hand-in-hand for supporting innovations in AI applications. Else, it can borrow them through partnerships and co-creation agreements, which will of course require anonymization of data.[76]

Partnerships with tech providers are highly recommended since they can help firms pool strengths and create more value in their ecosystem than if they operated independently.[77] Or if a firm has the resources to spare, to keep its data private when involved in partnerships, it can invest in its own data platform like J.P. Morgan did with Omni AI and Uber with Michelangelo. These platforms are helping the firms to get relevant data into their models much

74 University College London, *Enabling technology portfolio*, retrieved on December 18, 2020, https://www.ucl.ac.uk/intelligent-imaging-healthcare/about/enabling-technology-portfolio.

75 SAS Institute, *Artificial Intelligence: What it is and why it matters*, https://www.sas.com/nl_nl/insights/analytics/what-is-artificial-intelligence.html.
Michael J. Palma and Nina Turner, "Enabling Technologies: Artificial Intelligence Edge Processor Architectures," *International Data Corporation (IDC)*, https://www.idc.com/getdoc.jsp?containerId=IDC_P38120.

76 Laurence Capron and Will Mitchell, *Build, Borrow, or Buy* (Boston, MA: Harvard Business Review Press, 2012).
Francis J. Gouillart and Venkat Ramaswamy, *The Power of Co-Creation: Build It with Them to Boost Growth, Productivity, and Profits* (United Kingdom: Free Press, 2010).

77 Adam M. Brandenburger and Barry J. Nalebuff, *Co-opetition* (New York: Doubleday, 1996).

faster, build and deploy models seamlessly, and also help adhere to regulatory compliance, while retaining the data internally.[78]

The ORI factors, on the other hand, are more innate to incumbent firms than they realize. Even though AI technology is based mostly on open-source resources, making AI solutions very imitable, the less obvious resources, such as access to customers, are difficult to imitate.[79] This is a competitive advantage that any incumbent can easily leverage. Also, the ability to attract and invest in talent is often second nature to most successful large firms. Cultural change is the only Achilles' heel for most incumbents, but that's fixable with consistent effort and a strategic approach encouraging adaptability. Creating a learning center to integrate the knowledge and experience into the firm and disseminate across managerial levels is the foundation for creating a change culture.[80] Given the low barriers to entry in the space of AI technology, culture could be the defining factor for success.

One very important thing to note while considering this matrix is to have a clear use case in mind, one that leverages the firm's core competencies. This will make the ORI and TRI evaluation more tangible and inform clearer decisions. Especially for making long-term investments, it's advisable for the firm to identify specific use cases in the lines of business that are of priority to

78 Martin Giles, "JPMorgan's CIO Has Championed A Data Platform That Turbocharges AI," *Forbes: CIO Network*, December 12, 2019, https://www.forbes.com/sites/martingiles/2019/12/12/jpmorgan-chase-ai-banking-model/. Jeremy Hermann and Mike Del Balso, "Meet Michelangelo: Uber's Machine Learning Platform," *Uber Data* (blog), *Uber Engineering*, September 15, 2017, https://eng.uber.com/michelangelo-machine-learning-platform/.

79 Makadok, Richard, "Can first-mover and early-mover advantages be sustained in an industry with low barriers to entry/imitation?," *Strategic Management Journal* 19, no. 7 (1998): 683-696, https://www.jstor.org/stable/3094150.
Christine Oliver, "Sustainable Competitive Advantage: Combining Institutional and Resource-Based Views," *Strategic Management Journal* 18, no. 9 (1997): 697-713, https://www.jstor.org/stable/3088134.

80 Rita Gunther McGrath, Ian C. Macmillan, and Michael L. Tushman, "The role of executive team actions in shaping dominant designs: Towards the strategic shaping of technological progress," *Strategic Management Journal* 13 (1992): 137-161, https://doi.org/10.1002/smj.4250130910.
Satyendra Singh, Yolande E. Chan, and James D. McKeen, "Knowledge Management Capability and Organizational Performance: A Theoretical Foundation," *Organizational Learning, Knowledge and Capabilities Conference paper*, University of Warwick, Coventry, UK, March 20-22, 2006, https://warwick.ac.uk/fac/soc/wbs/conf/olkc/archive/olkc1/papers/144_singh.pdf.

its long-term competitive strategy, then figure out whether AI is needed and, if yes, determine how it should go about adopting it. The answer for "how" should first identify quantifiable success criteria; working out the rest like the economics, the people, and the systems can then follow. ■

Closing Word

AI has become ubiquitous and offers tremendous potential to alter our lives and the products and services companies provide. To understand how an organization can best leverage it will require an understanding of its boundary conditions along with its potential and the domains where it can be best put to use. The risk of doing nothing has to be contrasted with experimentation and learning.

The spillover effects of pursuing new technologies such as AI will include creating new knowledge in the firm and the result will be seen even in existing products and processes either through lowered costs or enhanced attractiveness.[81] Experimenting with a new technology to enter modest markets and then using that as a springboard to target other markets and domains can be a disruptive strategy for an incumbent.

Lastly, firms need to recognize that AI is both an art and a science and it's not all about a mathematical algorithm. Long-term investment in training and reskilling employees is key, and so is keeping an eye out for "AI winters," periods of historical investment drought that occur because of a sudden focus on AI's hype. ■

81 Wesley M. Cohen and Daniel A. Levinthal, "Absorptive capacity: A new perspective on learning and innovation," *Administrative Science Quarterly* 35, no. 1 (1990): 128-152, https://doi.org/10.2307/2393553.

Glossary: Understanding AI Terminology

Artificial intelligence (AI)

AI has many definitions as perceived by different authorities leading advances in the technology, but fundamentally they all refer to building machines that are capable of thinking like humans, or arguably, sometimes with above human intelligence. AI fits under the larger umbrella of computational intelligence.

Computational intelligence (CI)

The study of intelligent agents to 1) understand the principles that make intelligent behavior possible, and 2) design computational systems that perform intelligent tasks.[82] AI often denotes the latter part of CI that represents simulated intelligence. The phrase, "simulated intelligence" is debated since strong AI goes beyond simulation and displays independent patterns of thought and consciousness. But we are nowhere close creating strong AI, so we stick to the definition of AI as simulated intelligence.

Predictive analytics

Building analytical models using past data to identify patterns and relationships between input variables and the outcome variables for future outcomes. A model, trained with the past data, is then validated with more past data to match the actual past outcomes as accurately as possible. Once validated, the final model takes new input data and predicts the outcome so that the organization running the predictive model can preempt the customer's needs and capitalize on them, like Netflix's recommendations.

82 David Poole, Alan Mackworth, and Randy Goebel, "Computational Intelligence and Knowledge," chap. 1 in *Computational Intelligence: A Logical Approach* (New York: Oxford University Press, 1998), https://www.cs.ubc.ca/~poole/ci.html.

Machine learning (ML)

Employs self-learning by machines (unlike predictive analytics, which uses statistical techniques.) ML is considered a subset of AI, and exhibits the experiential "learning" associated with human intelligence and improves the performance of the computational algorithm as it learns without human involvement. For instance, with IBM Watson Health, the software is fed with "training data" of all possible data related to cancer diagnostics so that the software can recognize patterns in them, and when given the data of a new patient (test data) it can diagnose based on the learned pattern. Over time, it improves its precision by revising its original predictive model by both ingesting new data and learning from its own mistakes. Predictive accuracy thus improves with time and data.

Deep learning (DL)

A subfield of ML, with Neural Networks (NN) that contain neurons hundreds of layers deep. NN is used to create deeper and hierarchical layers of relationships between input variables in the data to assess their relative impact on the outcome for more accurate predictions.

Simply put, NN contains elementary data processing units called neurons, like in a human brain, which connect and transmit synapses or signals to other neurons. Each neuron takes input data, processes it through a complex mathematical function, and sends an output to its connected neurons. In DL, they are structured in layers with an input layer receiving external data and an output layer throwing out the ultimate output of the algorithm. Sandwiched between the two is a hidden layer of neurons (where data processing happens) with each neuron in each layer connecting with each one in the next layer. While this itself sounds sophisticated, imagine an NN with multiple such hidden layers! The computation gets very sophisticated very quickly. The greater the number of layers and neurons, the deeper the learning is. This architecture enables the neural net to learn non-intuitive and non-linear correlations among variables in the input data.

Because of its multiple connections of complex mathematical functions, DL allows for understanding data variables with relationships that are complex, non-obvious, non-linear, diverse, and unstructured.[83] That is, DL can find patterns in data that has no obvious relationship. Virtual assistants such as Siri and Alexa run on DL algorithms.

Machine/deep learning approaches can be broadly classified into supervised and unsupervised algorithms depending on how complex or unpredictable the input-output relationships are. In supervised learning the architecture of the model is specified by humans.[84] But when the architecture is decided by the machine itself, when relationships among variables are hard to detect for predicting an outcome, it becomes unsupervised learning. For example, unsupervised learning is best for detecting fraudulent transactions and anomalies.

CI is an evolving field, and some of the most successful AI systems are based on CI's three main pillars: neural networks, fuzzy systems, and evolutionary computation.[85]

> **Artificial neural networks,** or simply neural networks are a simulation of human brain with neurons or nodes connecting one another to create a sophisticated algorithm of analyzing data. Like Google's search algorithm.
>
> **Fuzzy systems** are designed using fuzzy sets (imprecise quantities) and fuzzy rules (common sense and inference) to model the concepts of the world and make decisions about it (fuzzy logic), like

83 Bernard Marr, "What Is Deep Learning AI? A Simple Guide With 8 Practical Examples," *Forbes: Enterprise Tech*, October 1, 2018, https://www.forbes.com/sites/bernardmarr/2018/10/01/what-is-deep-learning-ai-a-simple-guide-with-8-practical-examples/.

84 For instance, a neural network with four layers having 4, 16, 16, and 2 neurons or a classifier with a specific functional form.

85 IEEE Computational Intelligence Society, *What is Computational Intelligence*, retrieved on Dec 18, 2020, https://cis.ieee.org/about/what-is-ci.
Matthew Roos, "Evolutionary approaches towards AI: past, present, and future," *Towards Data Science*, October 15, 2019, https://towardsdatascience.com/evolutionary-approaches-towards-ai-past-present-and-future-b23c-cb424e98.

humans do: We can describe the weather as hot without precise numbers. Facial/image recognition technology uses fuzzy logic.

Evolutionary computation (EC) is inspired by biological evolution, where mathematical functions are optimized in an iterative fashion. Like coming up with trading strategies that are uncorrelated with others because the economic factors are dynamic, or optimizing traffic routes for self-driving cars to balance competing concerns.

While cognitive modeling, aka mimicking human intelligence, is not precise because human behavior is not entirely algorithmic, fuzzy logic or common sense with imprecise rules plays a significant role in developing AI agents; EC provides an opportunity to expand technical abilities beyond DL, toward exploration, paving the way to creative AI.

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